

—HIDOH / USGS Cooperative Program—

**Wastewater and Nutrient Source
Tracking – Results of
Reconnaissance Chemical Mapping
at Kualoa and Kahana, Oahu**

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Pacific Islands Water Science Center

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Partner / Program Linkages

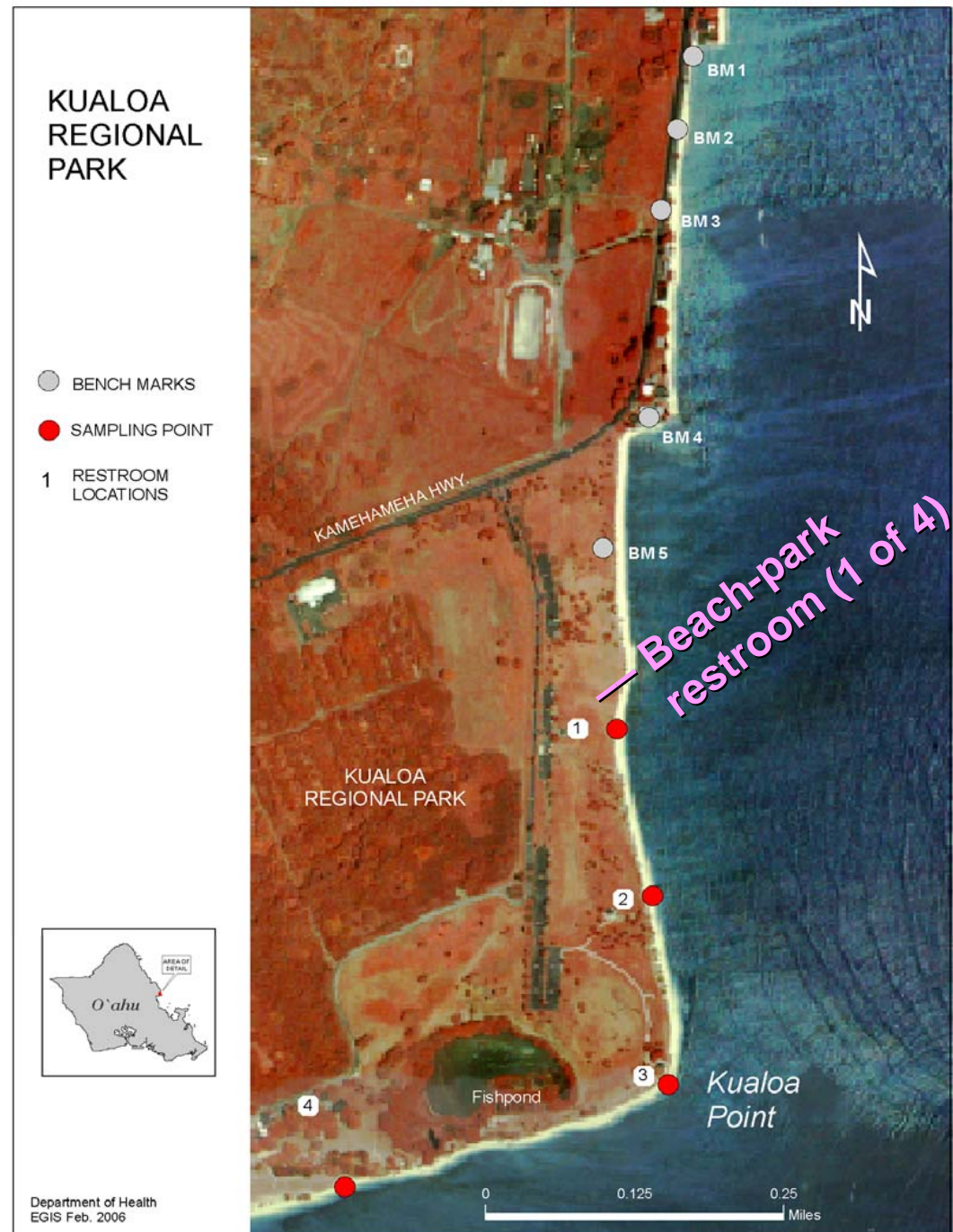
- Hawaii Department of Health (HIDOH)
 - Clean Water Branch—Beach monitoring
 - TMDL tie-in?
- USEPA program links
 - Clean Water Act
 - Beach Act
 - TMDL program?

Problem

- Beach Monitoring of Recreational Waters
 - High fecal indicator bacteria at fixed sites
 - Sources uncertain, ambiguous
 - Although septic wastewater is suspected ...
... we lack a convincing “picture” to sway decision makers, stakeholders
- TMDL
 - Would like nutrient “source attribution”

Kualoa

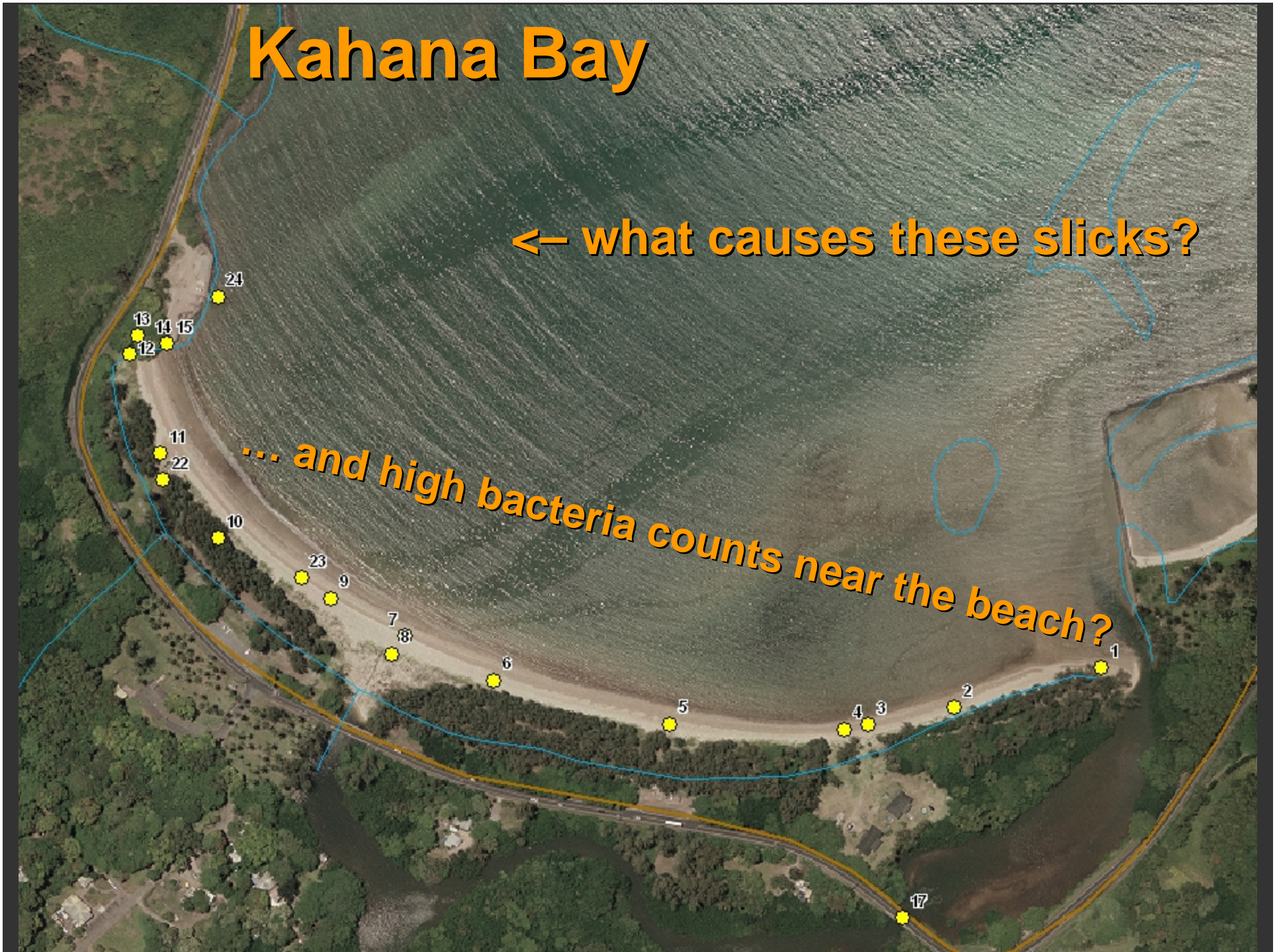
High bacterial counts at DOH fixed monitoring sites



Kahana Bay

← what causes these slicks?

... and high bacteria counts near the beach?



Beach Closure – Kualoa, Oahu



Photo: Jeff Widener, The Honolulu Advertiser

**Malfunctioning beach-park septic
systems may be a cause**

**Kualoa contamination nets
city \$300,000 fine**

**The release of sewage into the sea prompts the
state's penalty**

Honolulu Star-Bulletin

Feb 10, 2007

But There Are Non-Human Sources, Too

Pile of seaweed ?



... or Labrador Retriever ?

Photo: Jeff Widener, The Honolulu Advertiser

... the lighter side

Turtles key suspects in UFO* debate

* Unidentified Floating Object

Charles Memminger,
Honolulu Lite
Honolulu Star-Bulletin
Feb 19, 2006



Objectives and Approach

- Provide the “picture” or context via continuous mapping to aid interpretation of fixed-site data
- In-house DOH method for rapid reconnaissance
- Conduct proof-of-concept surveys, evaluate success, identify needed refinements
- Tiered approach - cheap mapping first, expensive lab analyses later
- Multi-tracer approach

Case-Study Surveys

Completed:

- Kualoa Beach, Oahu—Beach monitoring
 - Shoreline wading surveys (2)
 - Beach porewater transect (25 samples)
- Kahana Bay, Oahu—Beach monitoring
 - Beach porewater transect (25 samples)

Future:

- Hanalei, Kauai—Beach monitoring, TMDL
- Kaelepulu Pond, Oahu—TMDL

Conclusions

Overall

Kualoa Beach

Restrooms

North cove and farther

Kahana Bay

Punaluu Beach Park

NW cove

- **Wading & porewater methods have proven out → interpretable maps**

- **No** strong multi-tracer wastewater signature; slight indication NO_3 & PO_4

- **Probable animal / human waste signature; enhanced GW discharge**

- **Strong** multi-tracer wastewater signature; good septic endmember

- **No** strong multi-tracer wastewater signature; enhanced GW discharge, denitrification (of natural N?)

Multiple Tracers

Tracer

Possible Indicator of:

Salinity

Freshwater discharge (stream, GW)

NO_3 , NH_4 , PO_4

Animal / human waste, fertilizers

^{15}N , ^{18}O of NO_3

Animal vs plant NO_3 , denitrification

^2H , ^{18}O of H_2O

Water origin, evaporation, mixing

^{11}B

Laundry detergents (low ^{11}B)

Fluorescence

Fabric brighteners in detergents

Pharmaceuticals

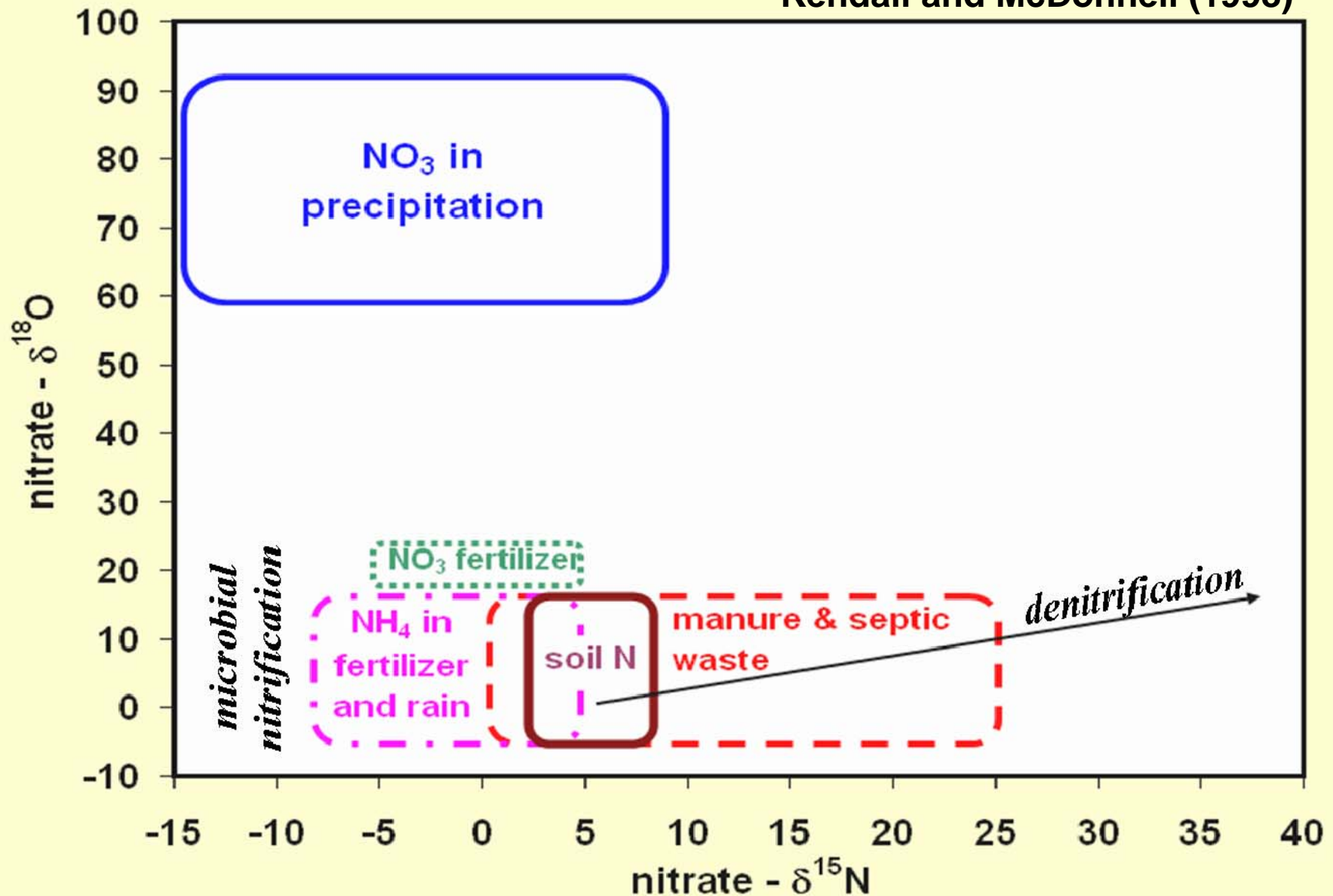
Household wastewater

WW compounds

Household wastewater

Example Tracer - ^{15}N of Nitrate Sources

Kendall and McDonnell (1998)



Mapping, Transecting Methods

- Wading instrument surveys (continuous)
 - GPS “trackline” fixes at 30-sec intervals
 - Multiparameter—Salinity, DO, chlorophyll, etc
 - Coming soon—fabric-brightener fluorescence
- Wading dip samples (fewer discrete points)
 - Fabric-brightener fluorescence, handheld meter
 - GPS “waypoint” fixes
- Beach porewater transects (discrete sites)
 - Lab analyses for various tracers

DOH Wading Platform

Multiparameter
water-quality
sensor

Logger
and GPS



Photo: Joshua Marvit, Hawaii Dept. of Health

Shoreline wading survey in knee-deep water



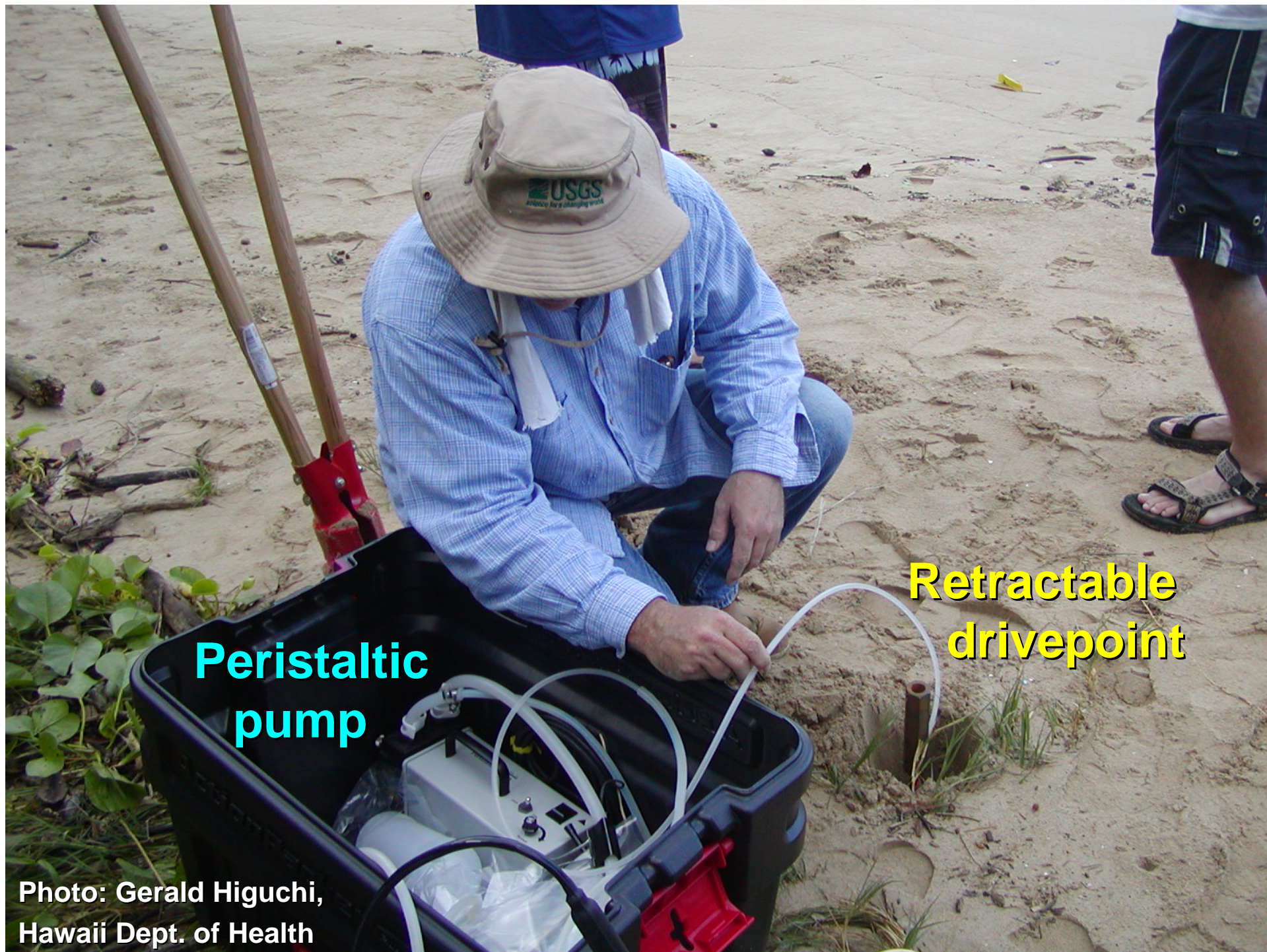
Photo: Joshua Marvit, Hawaii Dept. of Health

Beach Porewater Sampling

Retractable drivepoint & hammer drill

Photo: Gerald Higuchi, Hawaii Dept. of Health





**Peristaltic
pump**

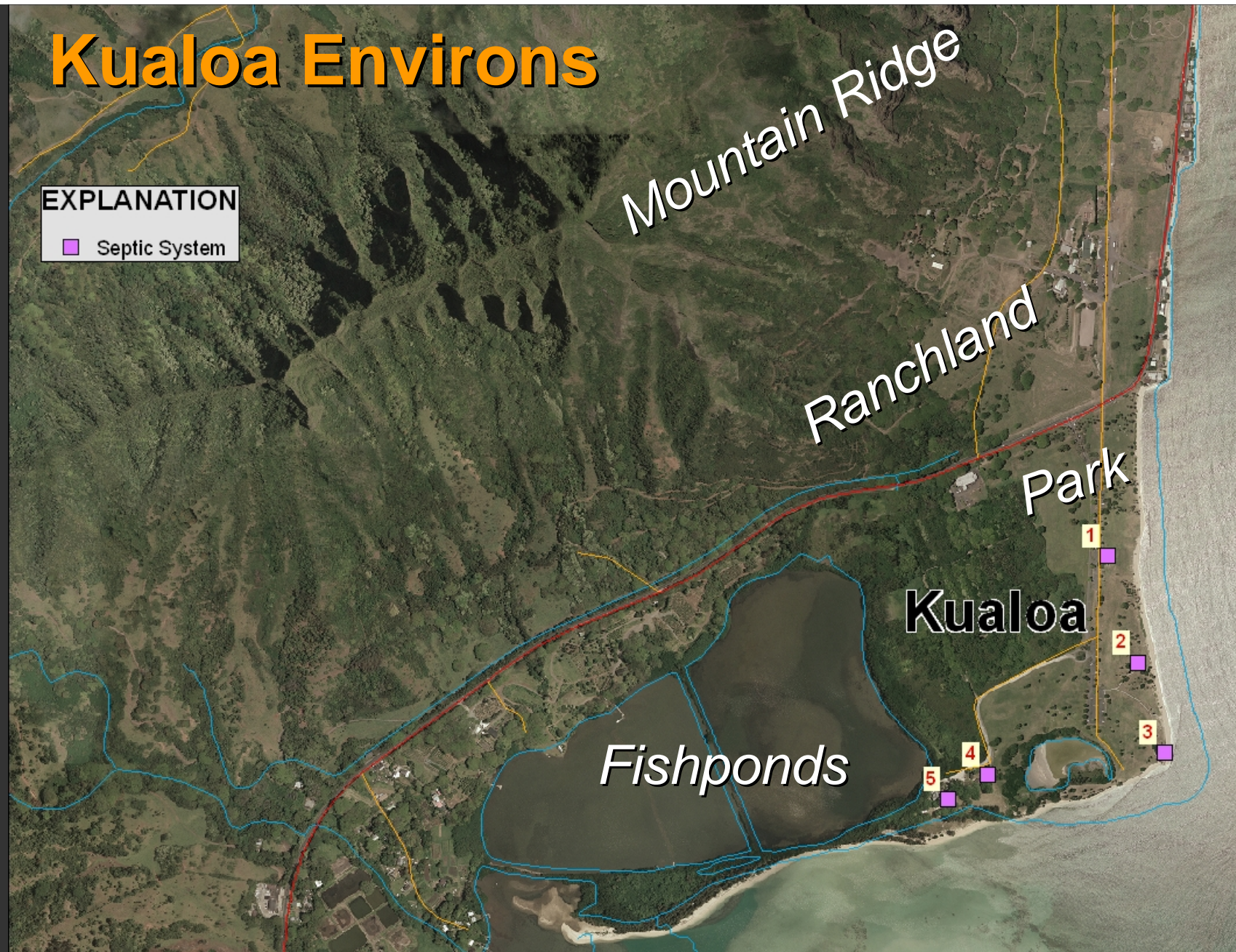
**Retractable
drivepoint**

**Photo: Gerald Higuchi,
Hawaii Dept. of Health**

Kualoa Environs

EXPLANATION

■ Septic System



Mar 3, 2006



Photo: Craig T. Kojima, Honolulu Star-Bulletin



Stormwater swale

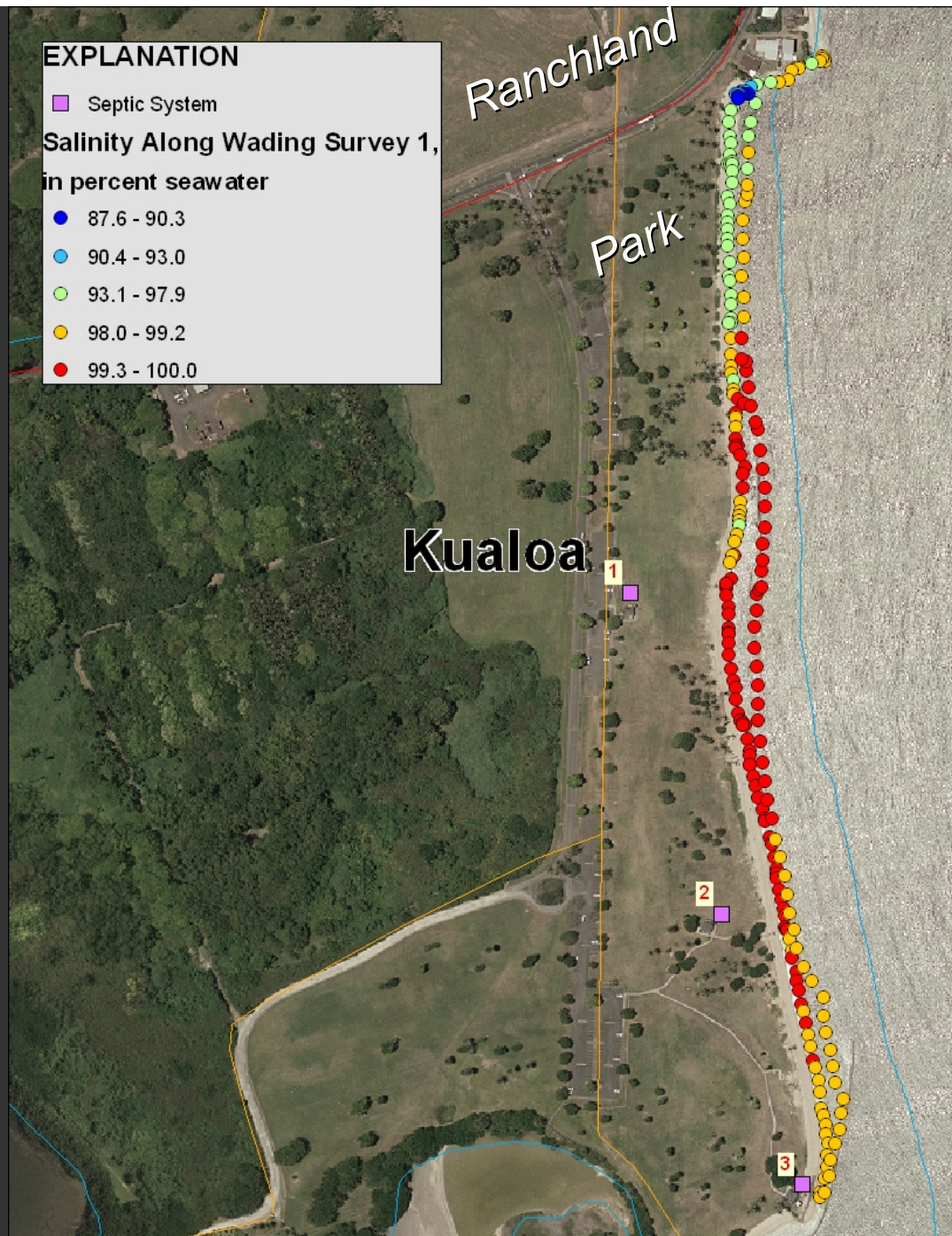
Photo: Joshua Marvit, Hawaii Dept. of Health

EXPLANATION

■ Septic System

**Salinity Along Wading Survey 1,
in percent seawater**

- 87.6 - 90.3
- 90.4 - 93.0
- 93.1 - 97.9
- 98.0 - 99.2
- 99.3 - 100.0



EXPLANATION

■ Septic System

**Salinity Along Wading Survey 1,
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- 87.6 - 90.3
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- 93.1 - 97.9
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- 99.3 - 100.0

Kualoa

1

2

3

EXPLANATION

Chlorophyll-a Along Wading Survey 1,
in micrograms per liter

● 0.18 - 0.45

● 0.45 - 0.88

● 0.88 - 1.74

● 1.74 - 2.90

● 2.90 - 5.93

■ Septic System

Kualoa

1

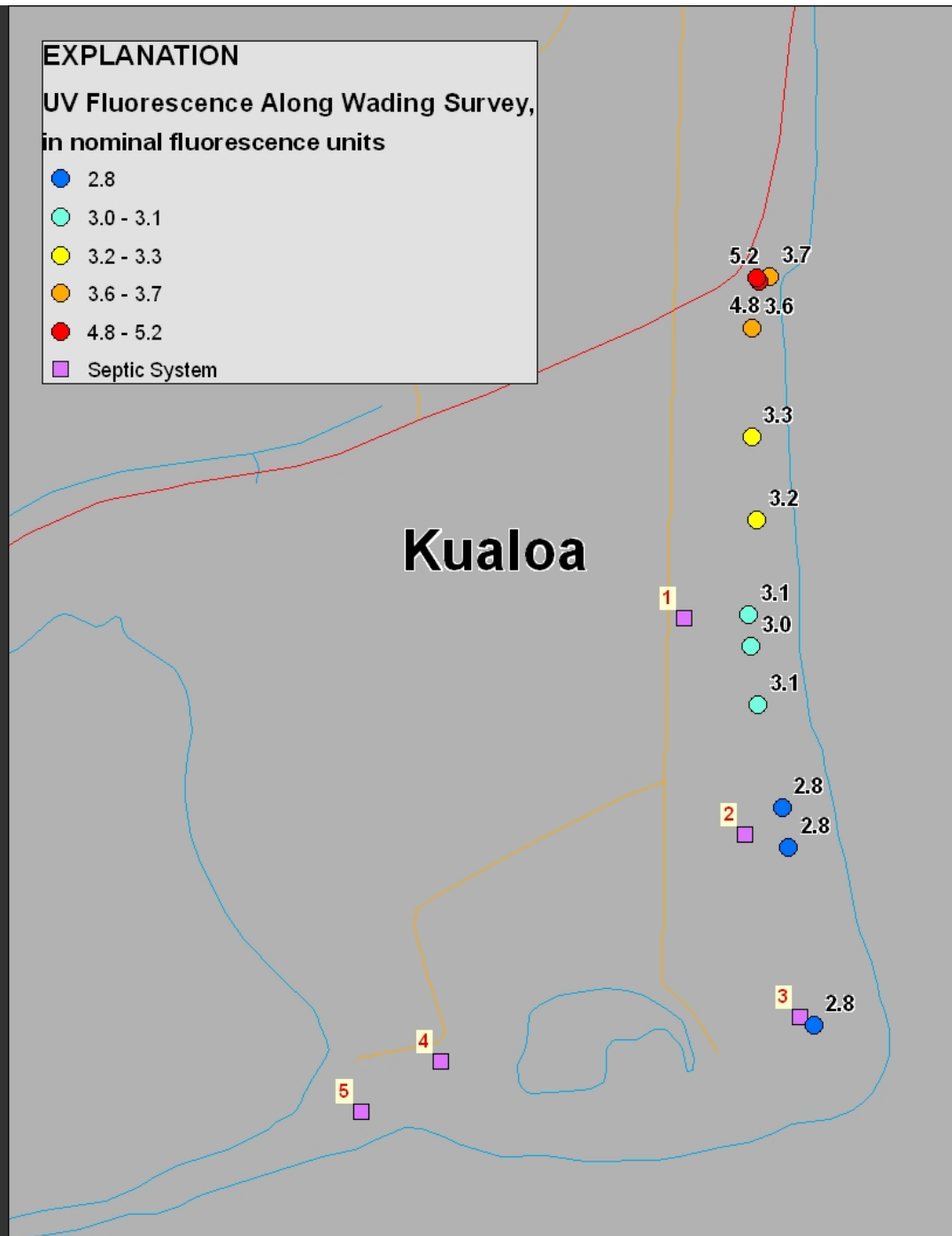
2

3

EXPLANATION

UV Fluorescence Along Wading Survey,
in nominal fluorescence units

- 2.8
- 3.0 - 3.1
- 3.2 - 3.3
- 3.6 - 3.7
- 4.8 - 5.2
- Septic System

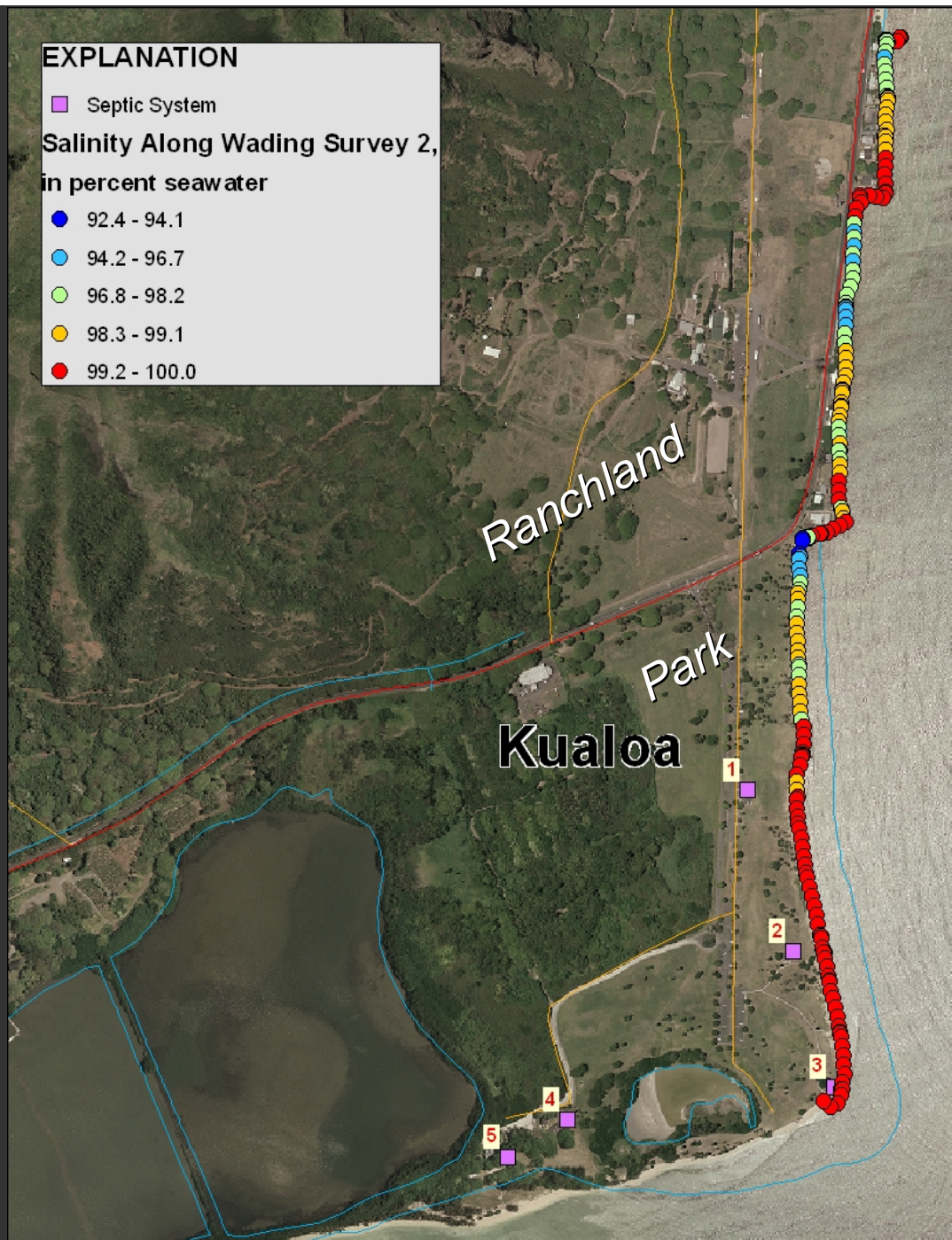


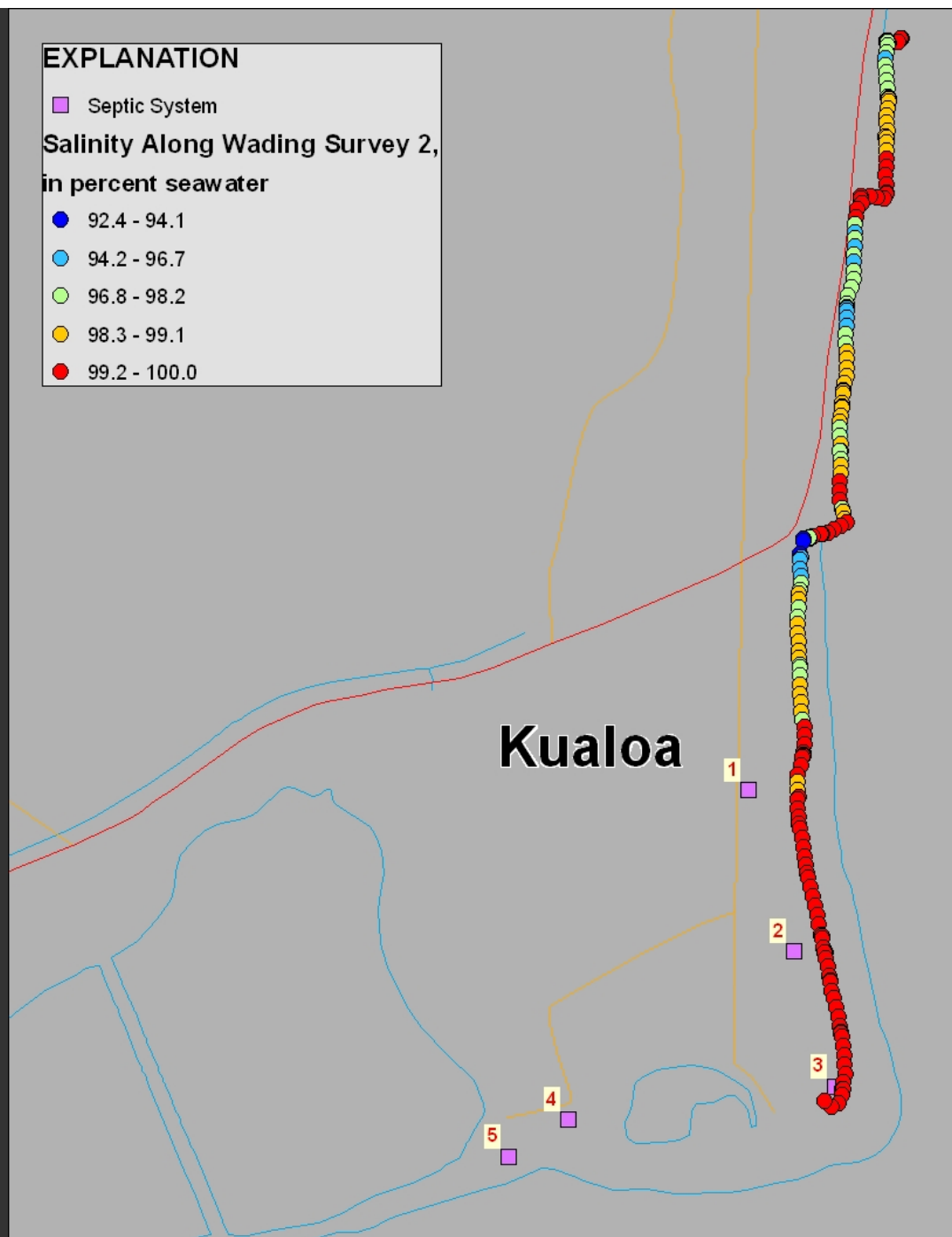
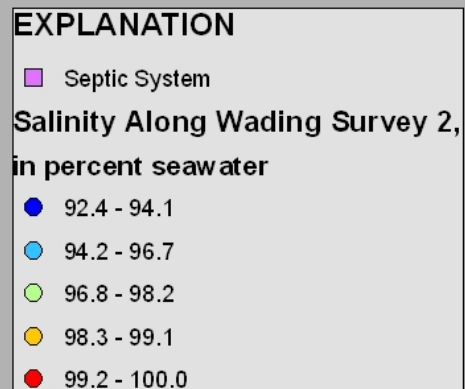
EXPLANATION

■ Septic System

**Salinity Along Wading Survey 2,
in percent seawater**

- 92.4 - 94.1
- 94.2 - 96.7
- 96.8 - 98.2
- 98.3 - 99.1
- 99.2 - 100.0

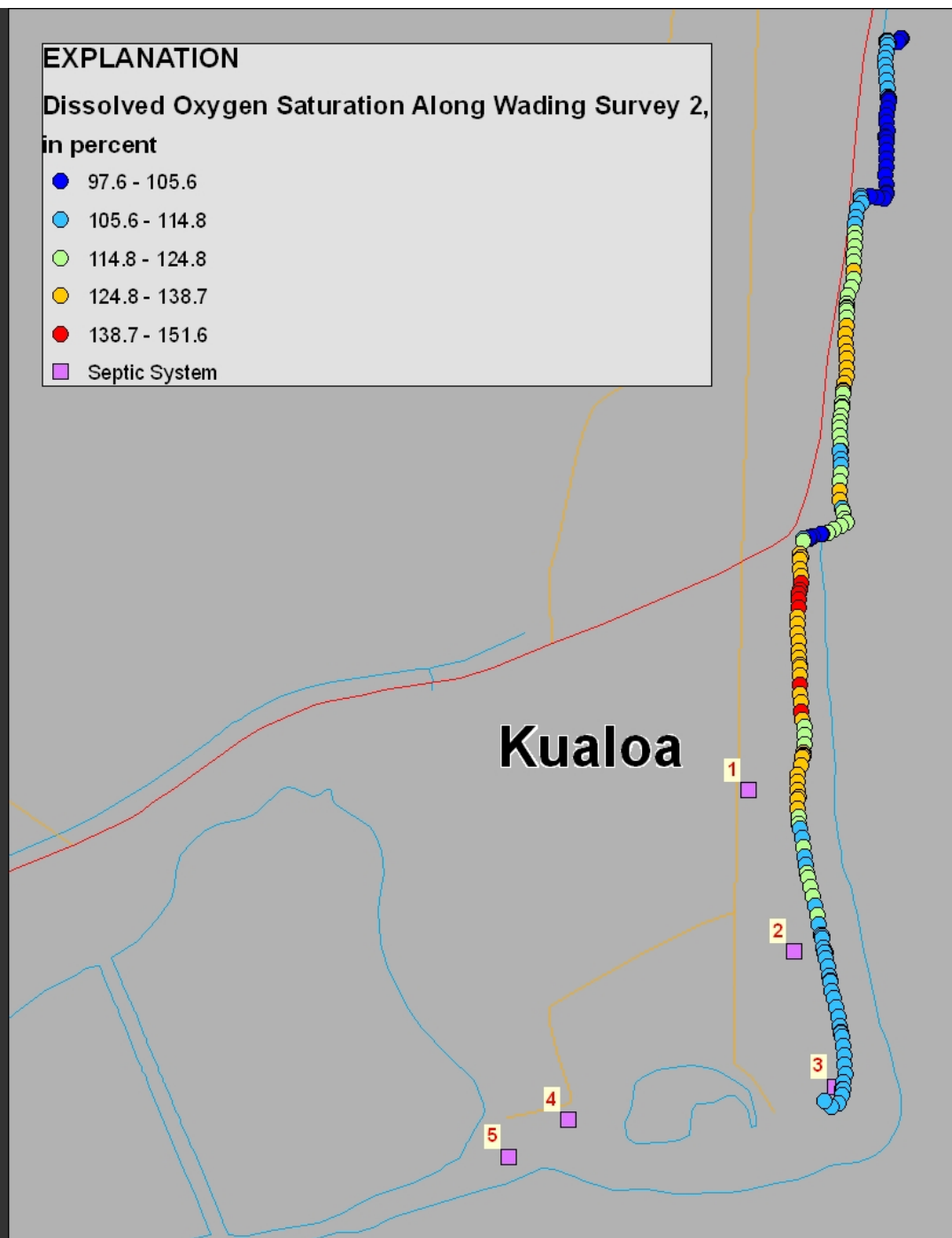




EXPLANATION

Dissolved Oxygen Saturation Along Wading Survey 2,
in percent

- 97.6 - 105.6
- 105.6 - 114.8
- 114.8 - 124.8
- 124.8 - 138.7
- 138.7 - 151.6
- Septic System

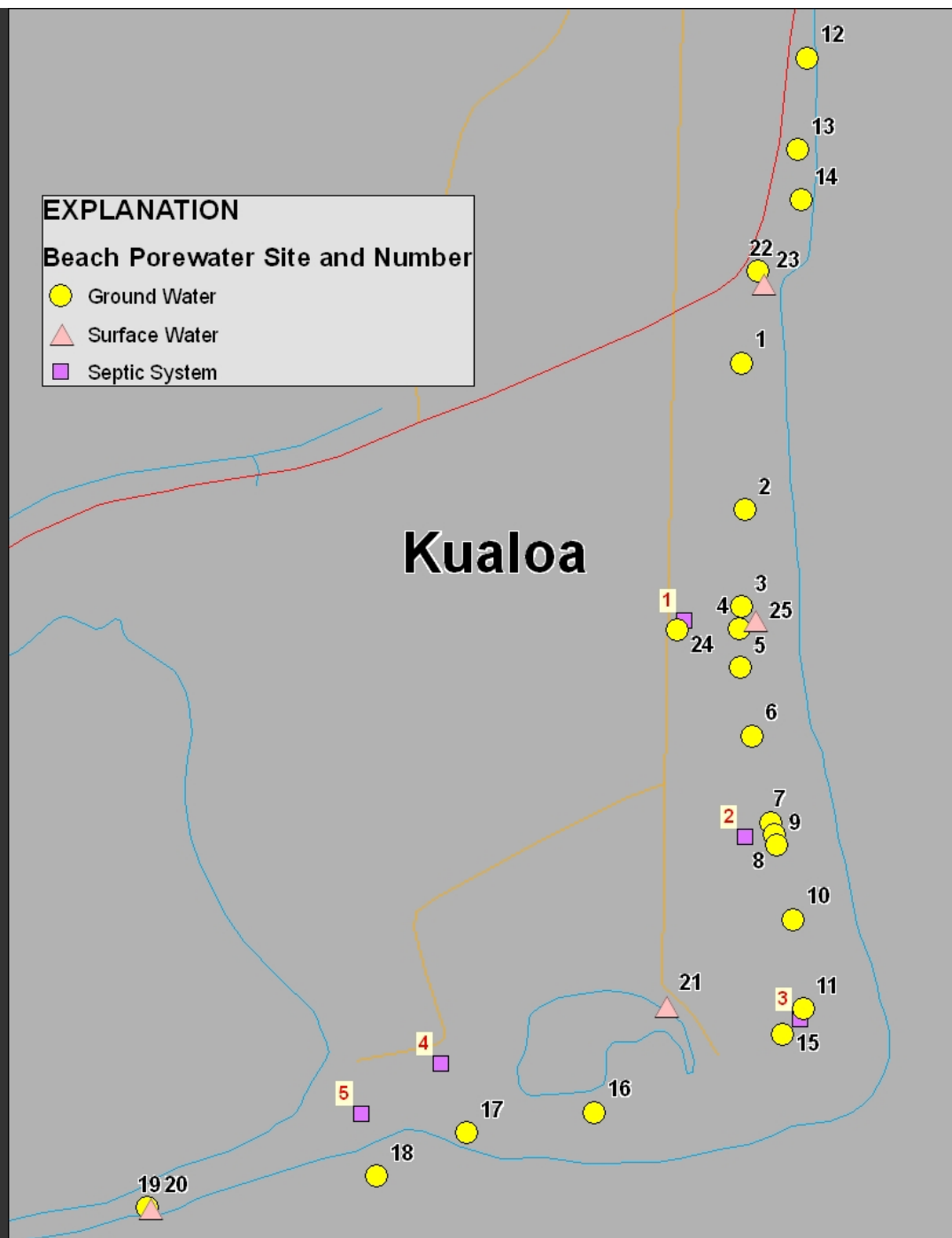


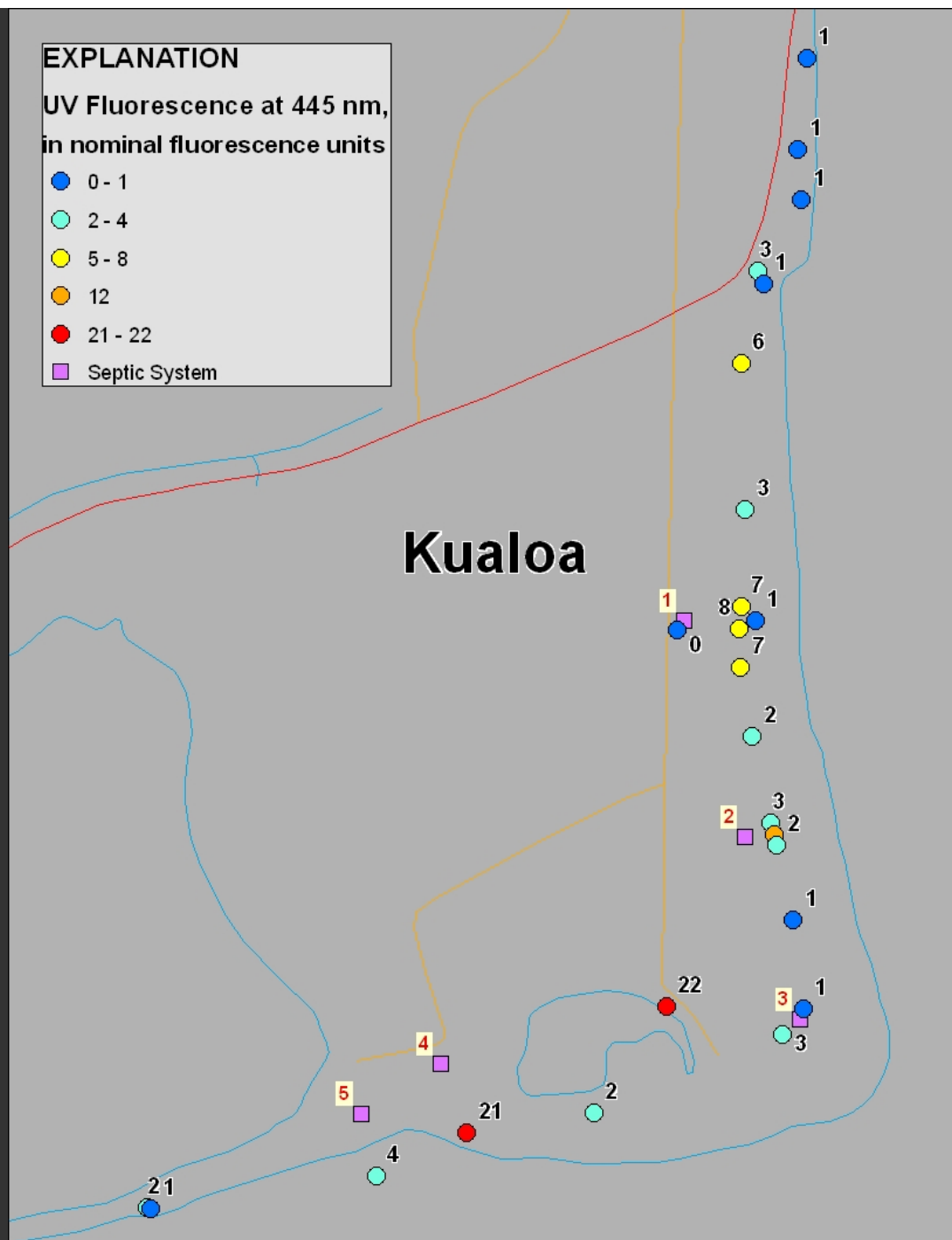
EXPLANATION

Beach Porewater Site and Number

- Ground Water
- Surface Water
- Septic System

Kualoa





EXPLANATION

Delta-11B in Water,
in per mil

○ Not analyzed

● 39.5

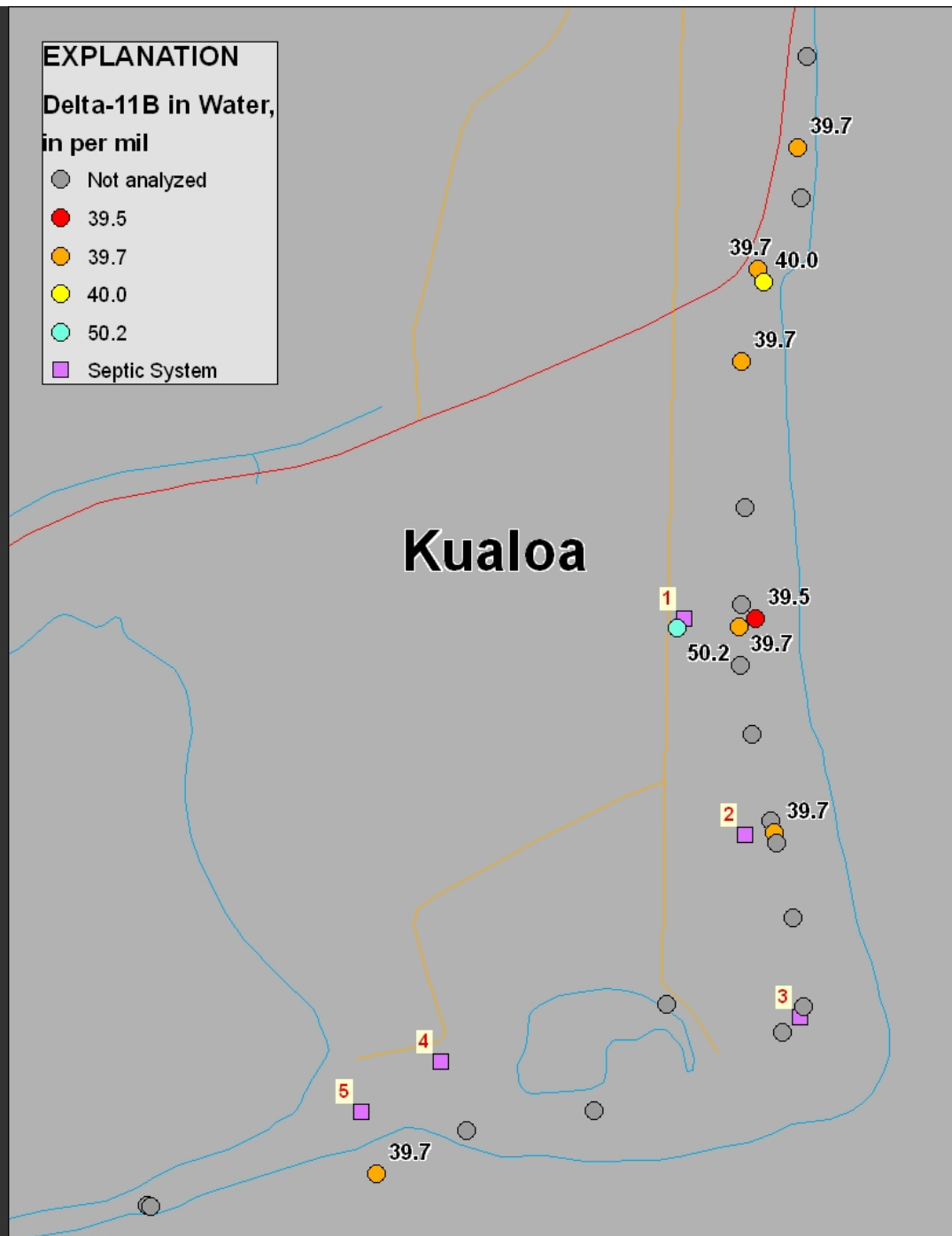
● 39.7

● 40.0

● 50.2

■ Septic System

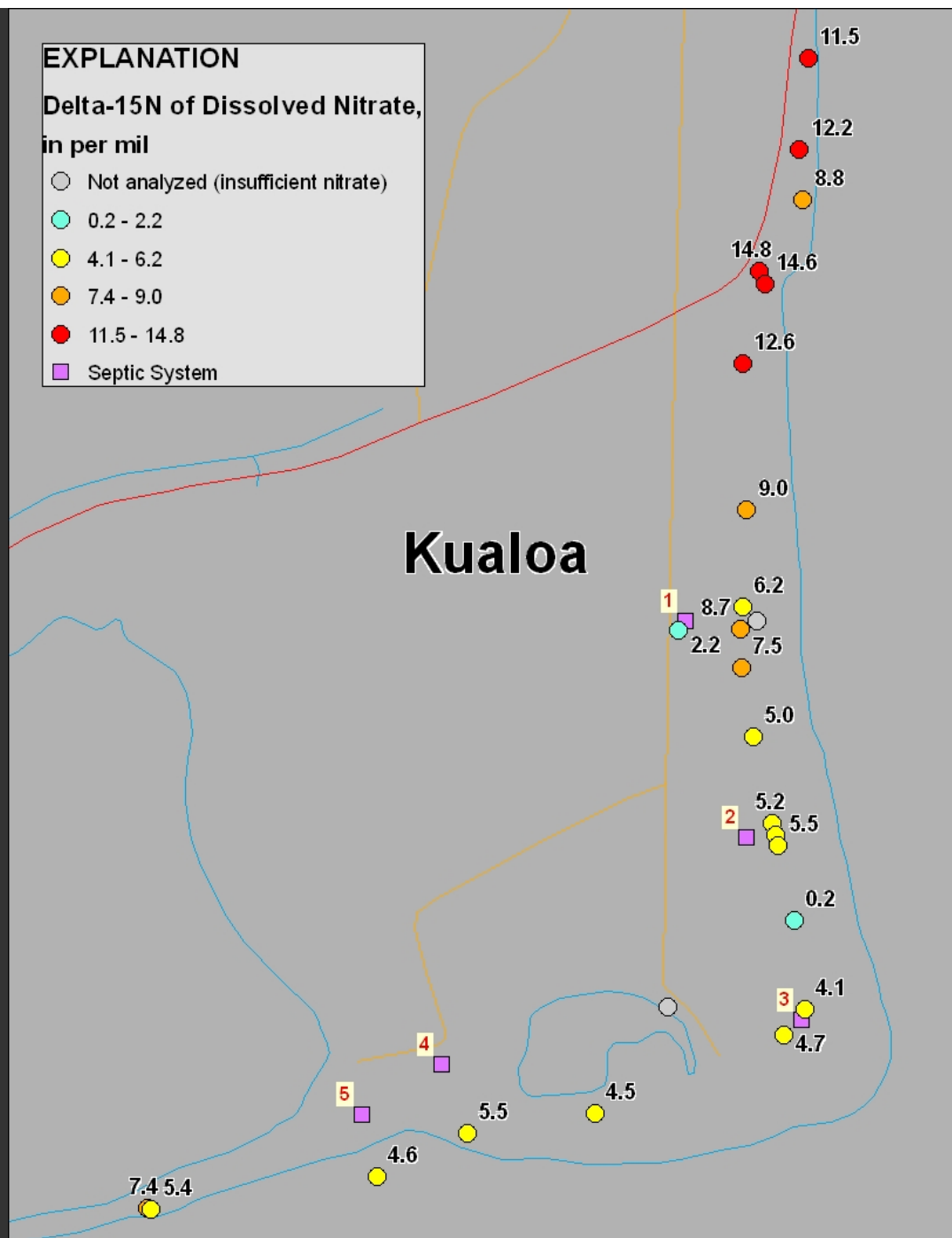
Kualoa

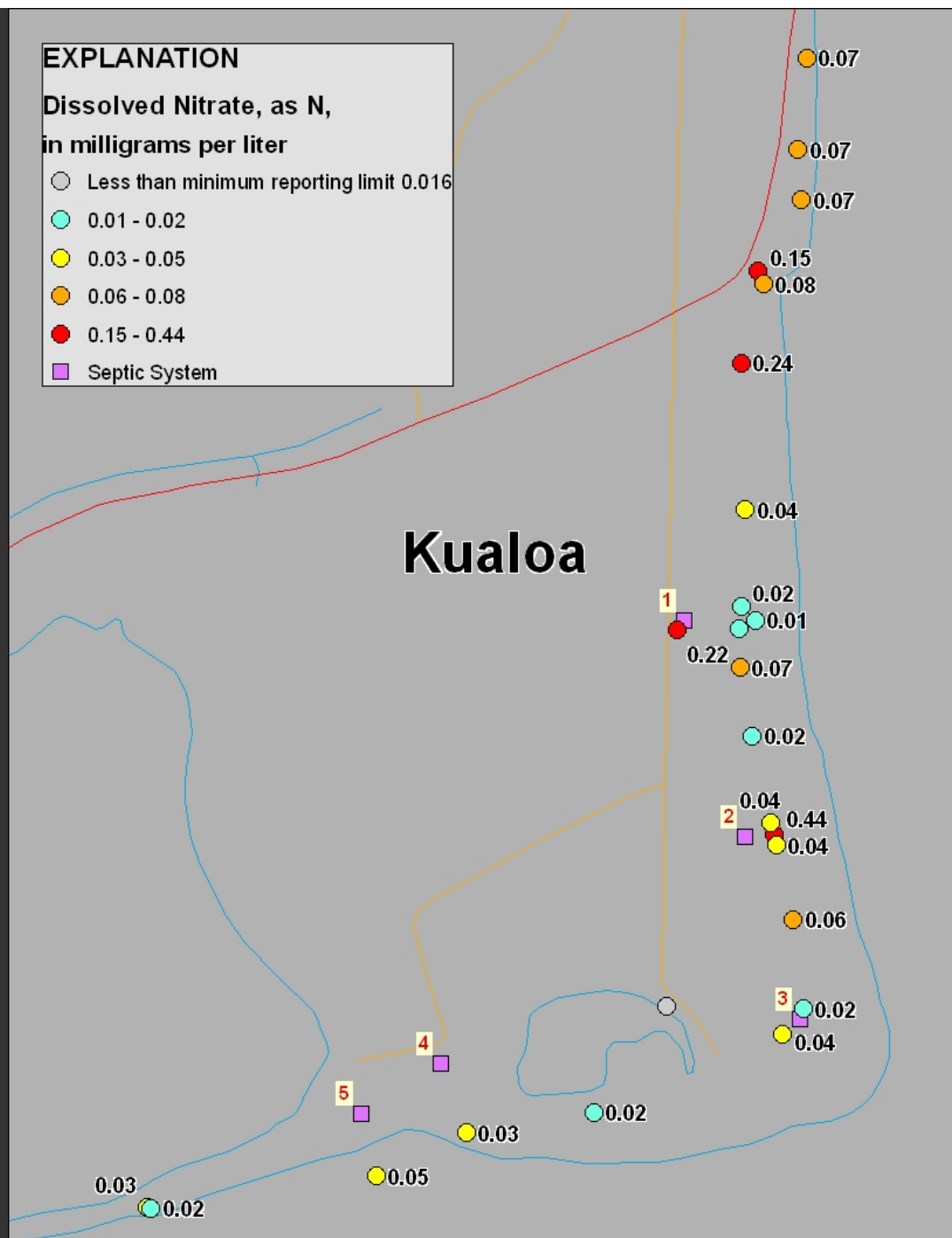
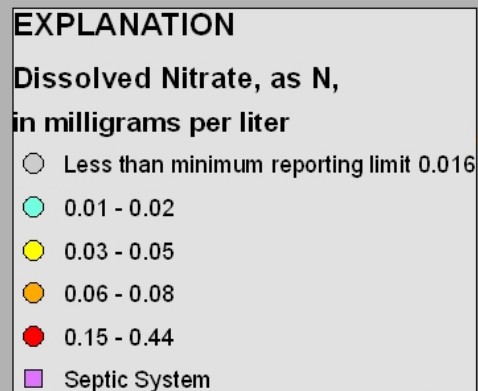


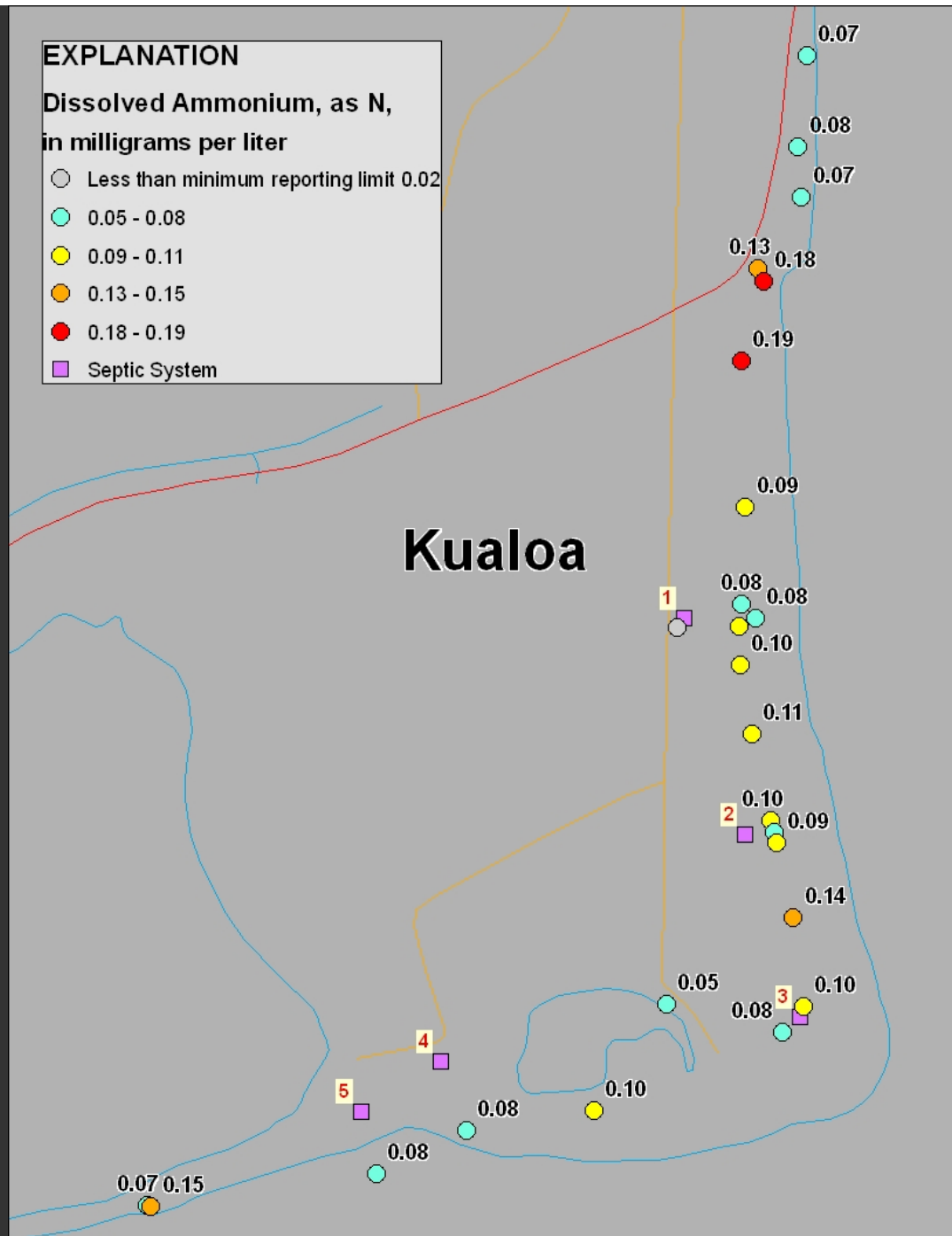
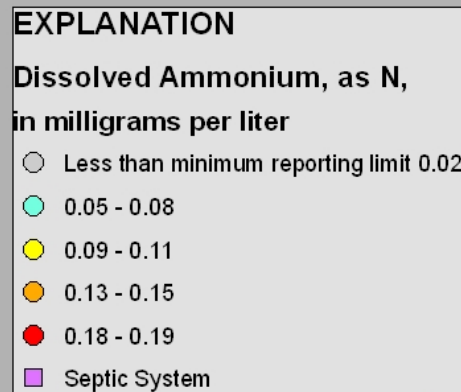
EXPLANATION

**Delta-15N of Dissolved Nitrate,
in per mil**

- Not analyzed (insufficient nitrate)
- 0.2 - 2.2
- 4.1 - 6.2
- 7.4 - 9.0
- 11.5 - 14.8
- Septic System







EXPLANATION

Dissolved Orthophosphorus, as P,
in milligrams per liter

● 0.004 - 0.006

● 0.009 - 0.012

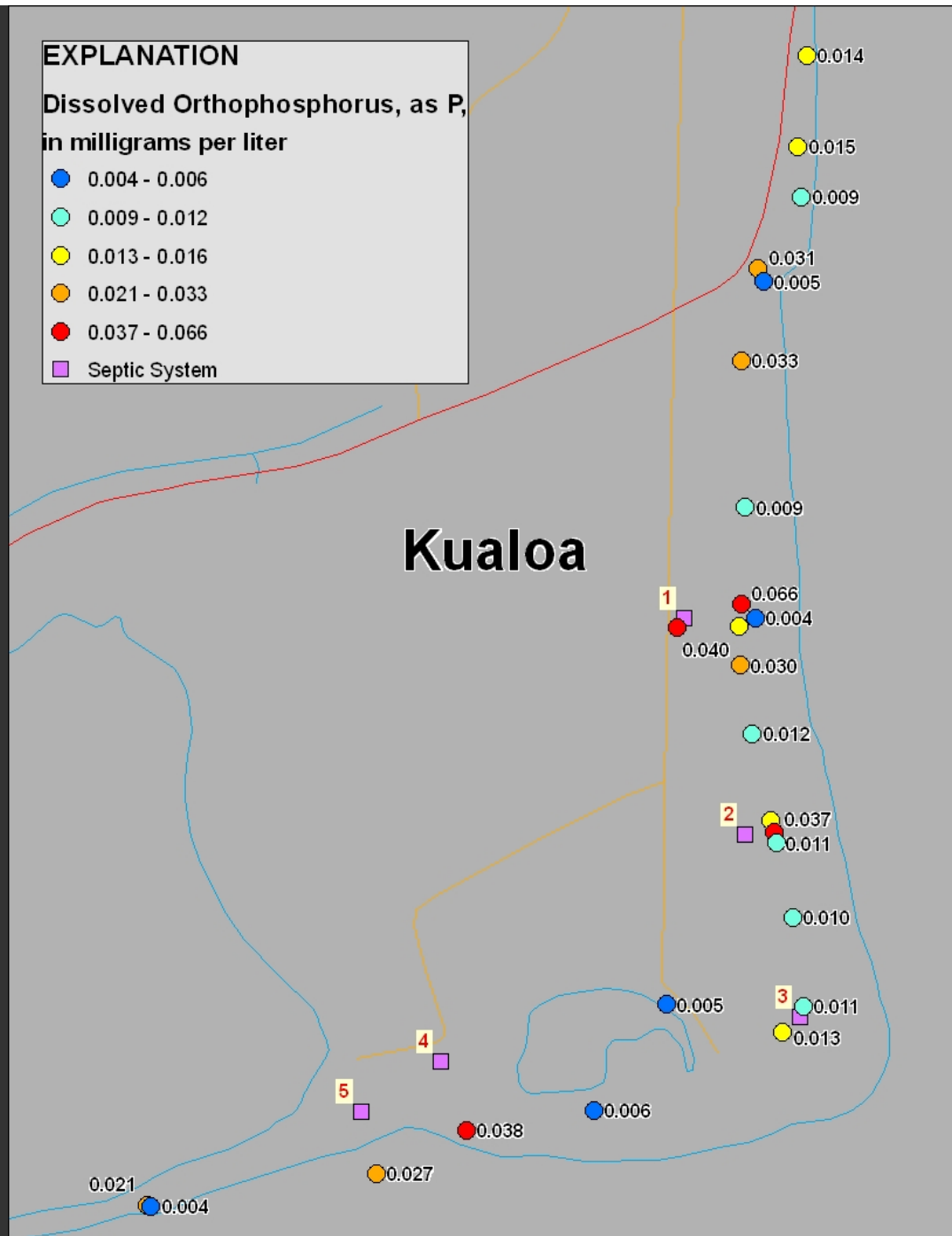
● 0.013 - 0.016

● 0.021 - 0.033

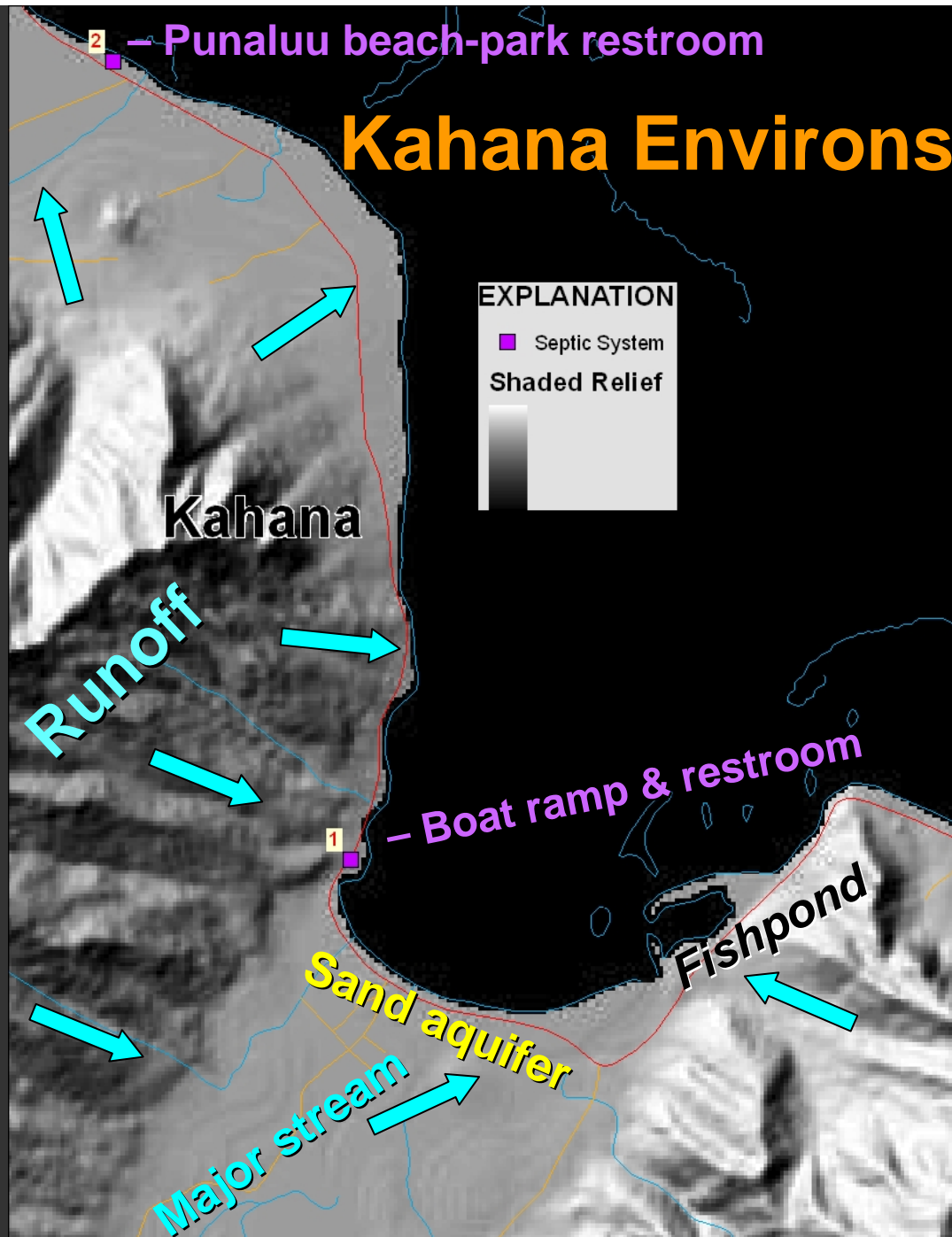
● 0.037 - 0.066

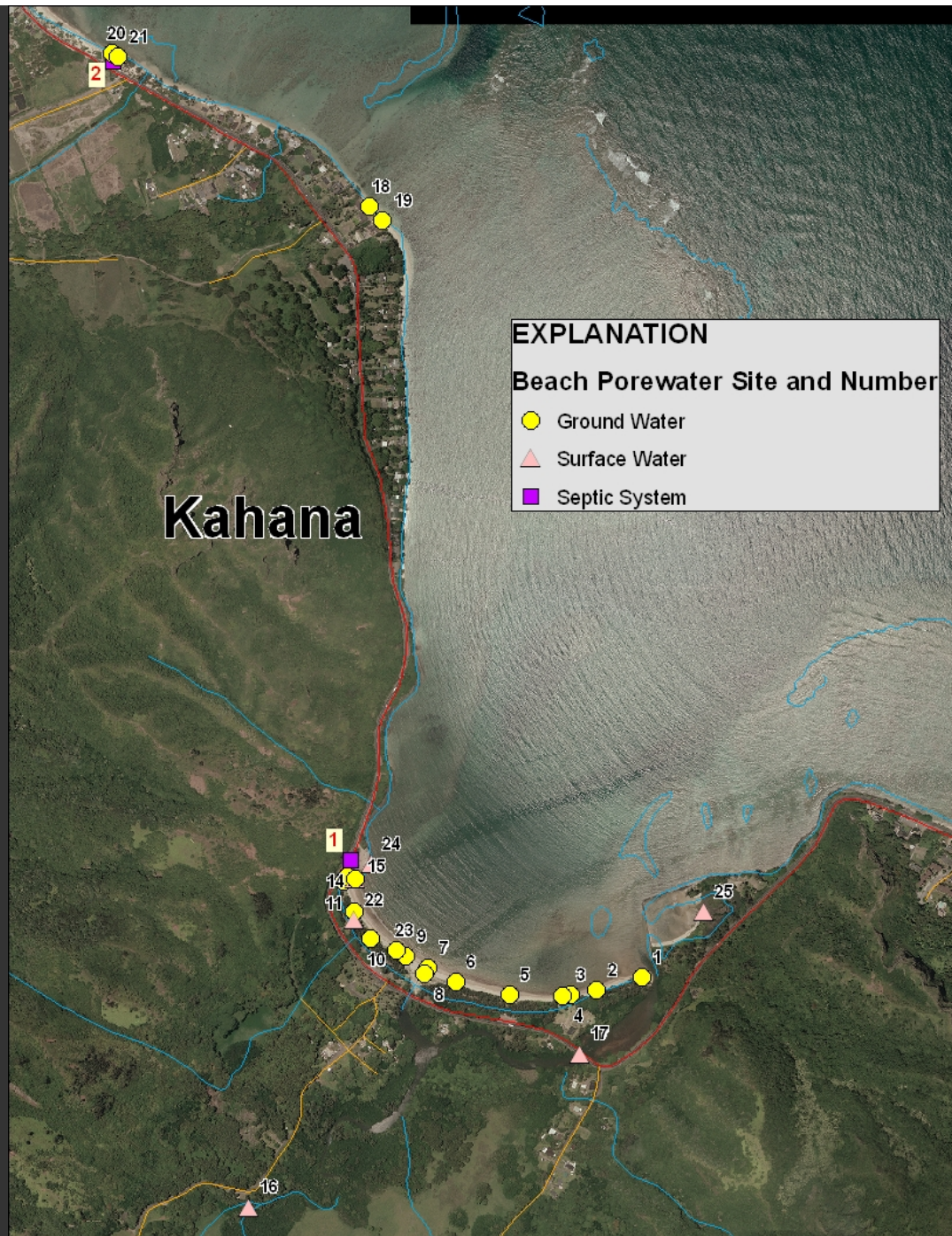
■ Septic System

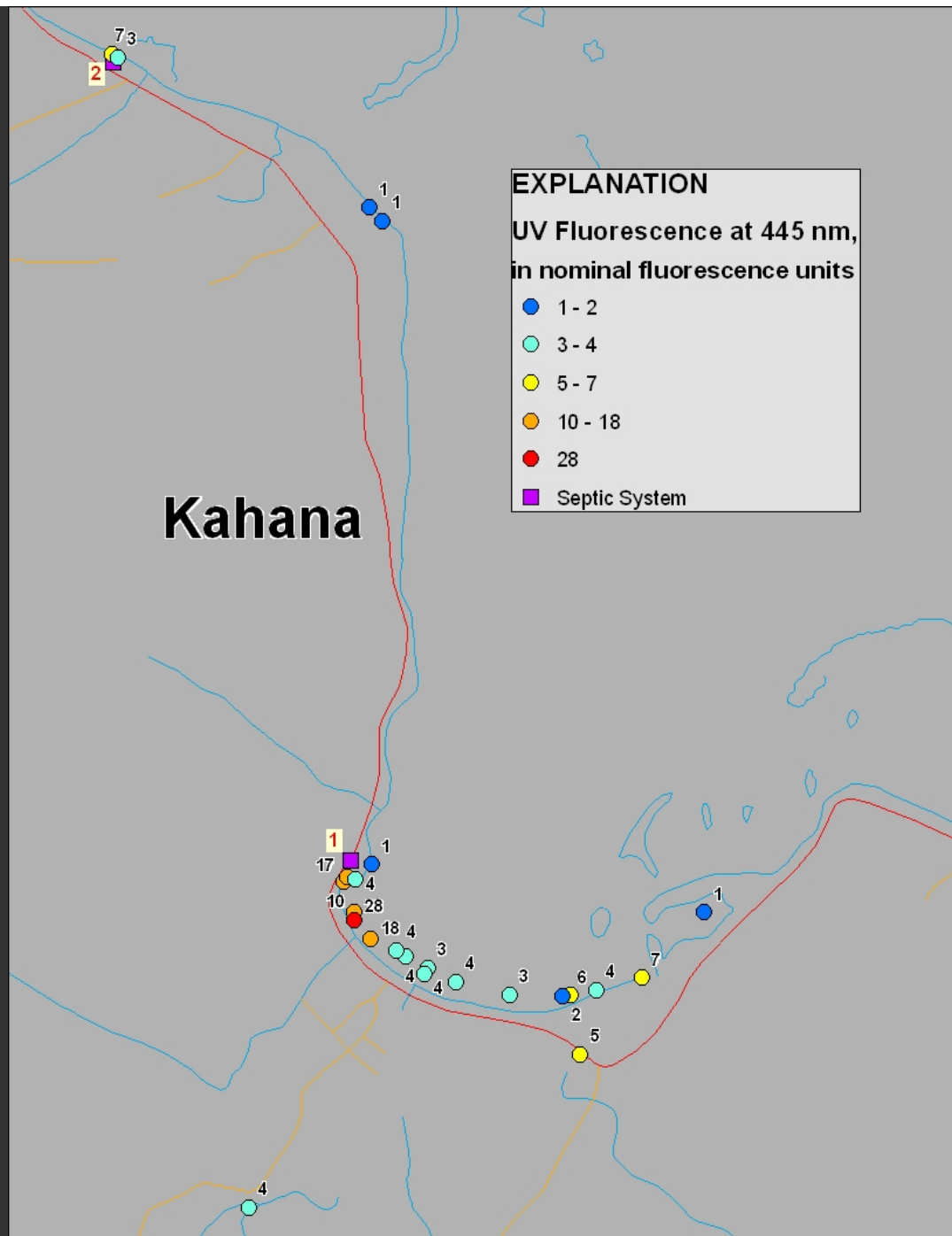
Kualoa

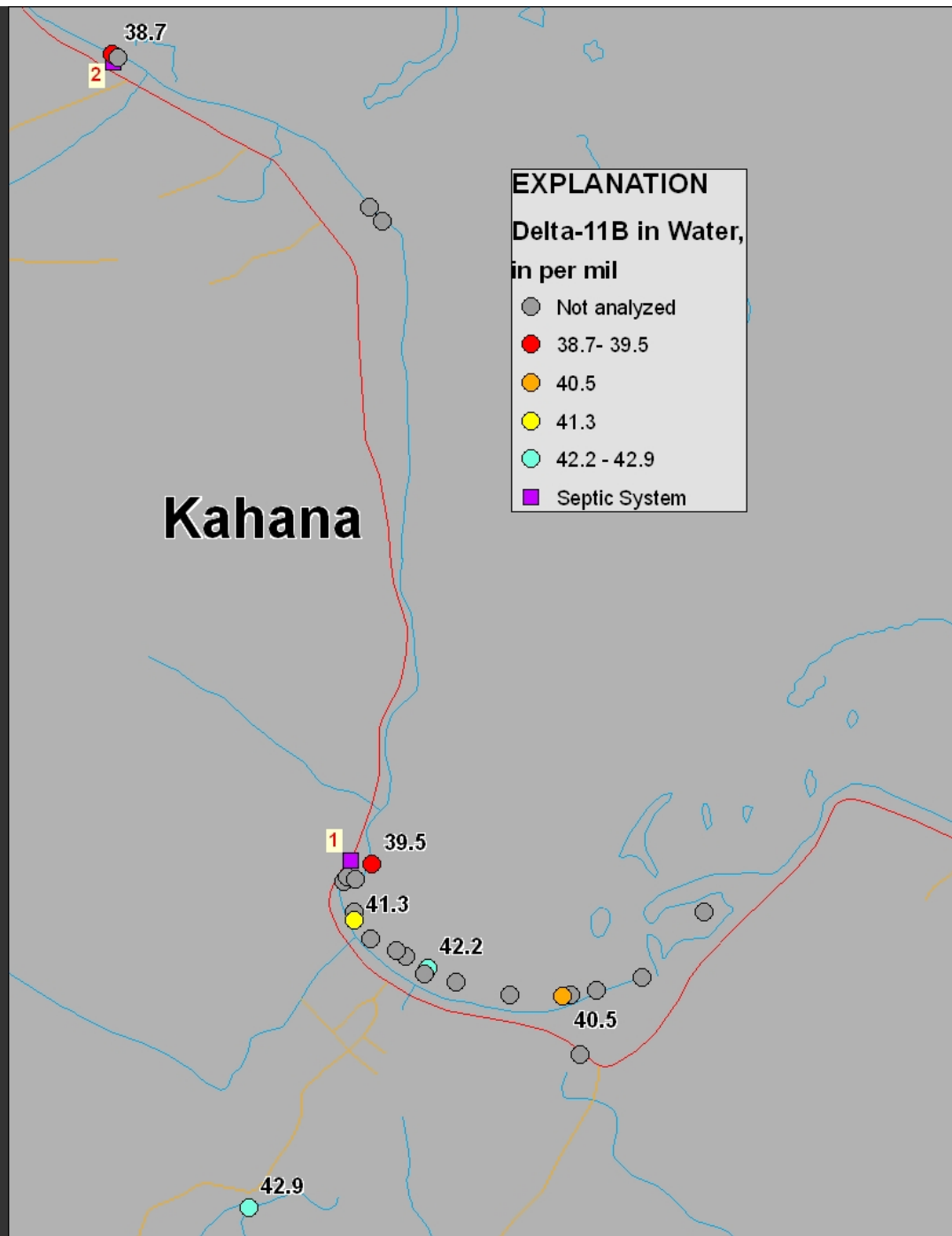


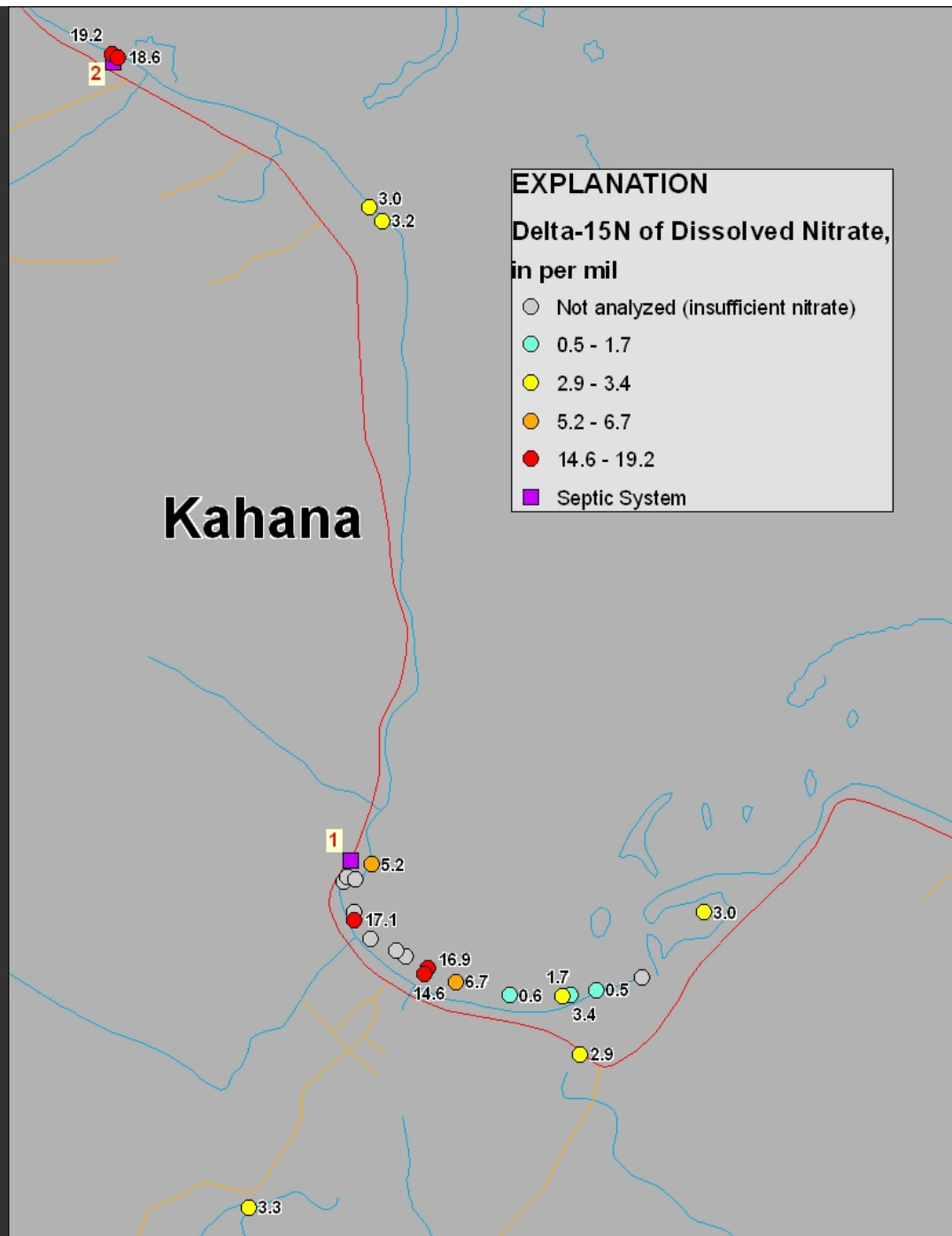
Kahana Environs











Kahana

EXPLANATION

Dissolved Ammonium, as N,
in milligrams per liter

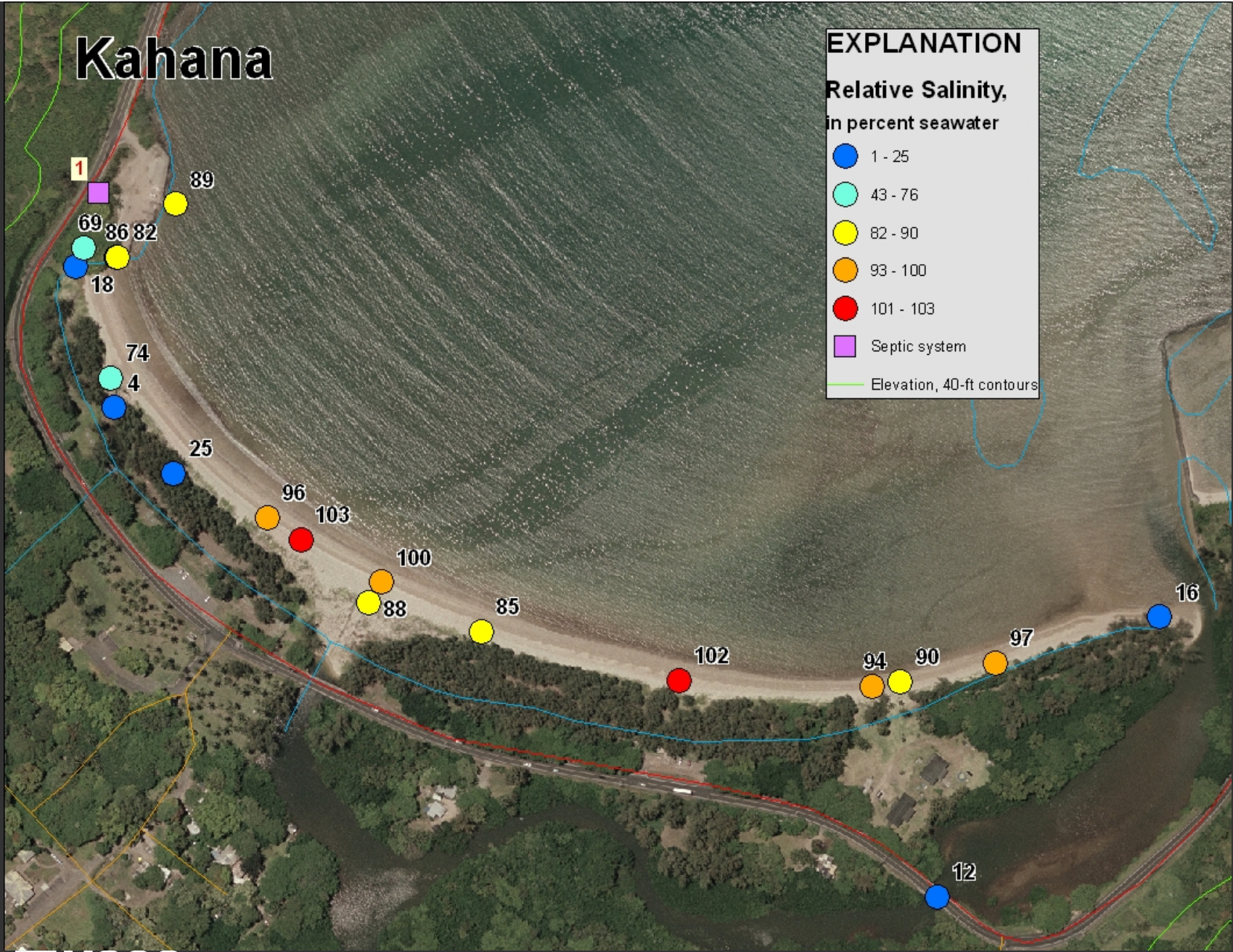
- Less than minimum reporting limit 0.02
- 0.01 - 0.05
- 0.08 - 0.16
- 0.19 - 0.31
- 1.10
- Septic System

Kahana

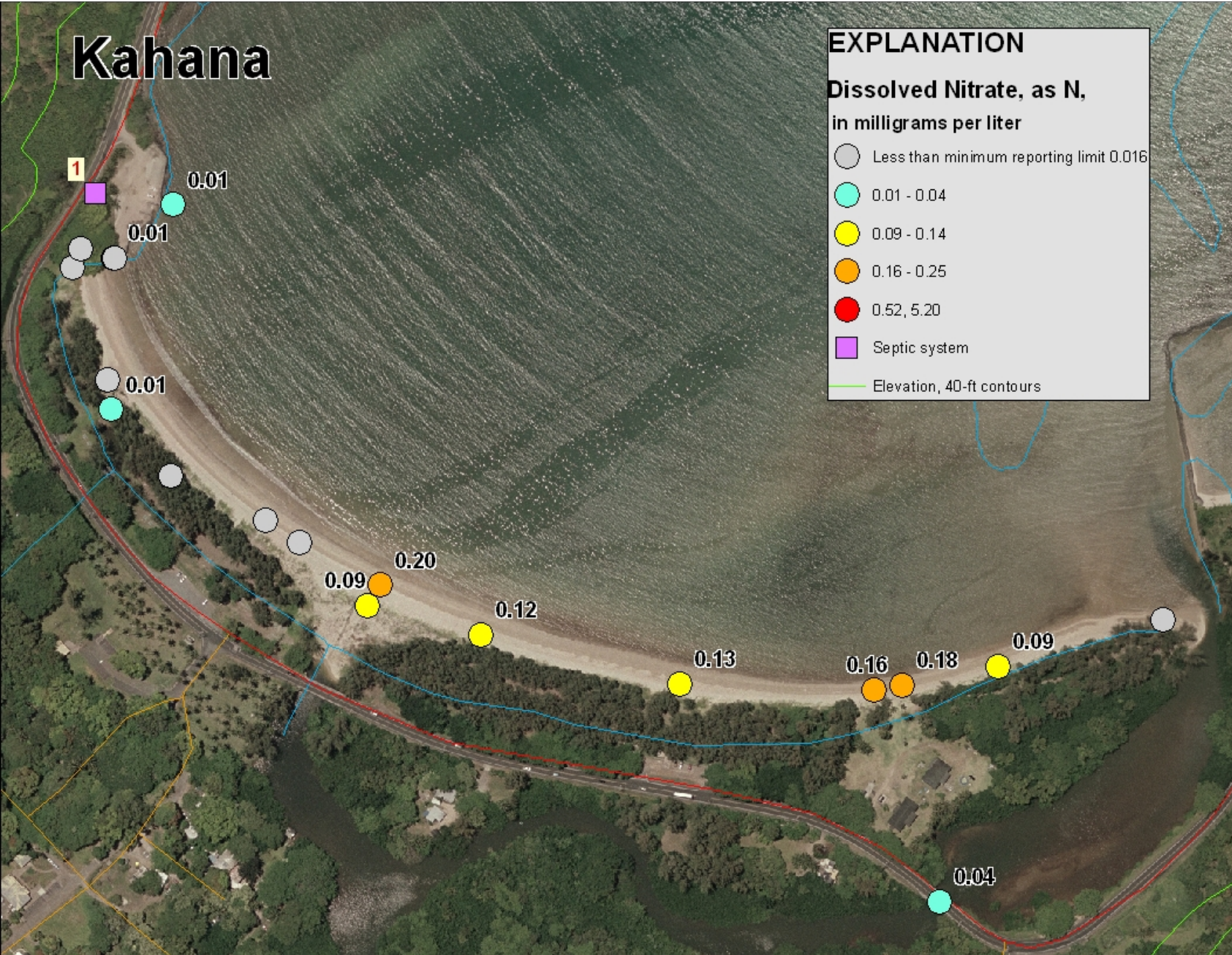
EXPLANATION

Relative Salinity,
in percent seawater

- 1 - 25
- 43 - 76
- 82 - 90
- 93 - 100
- 101 - 103
- Septic system
- Elevation, 40-ft contours



Kahana

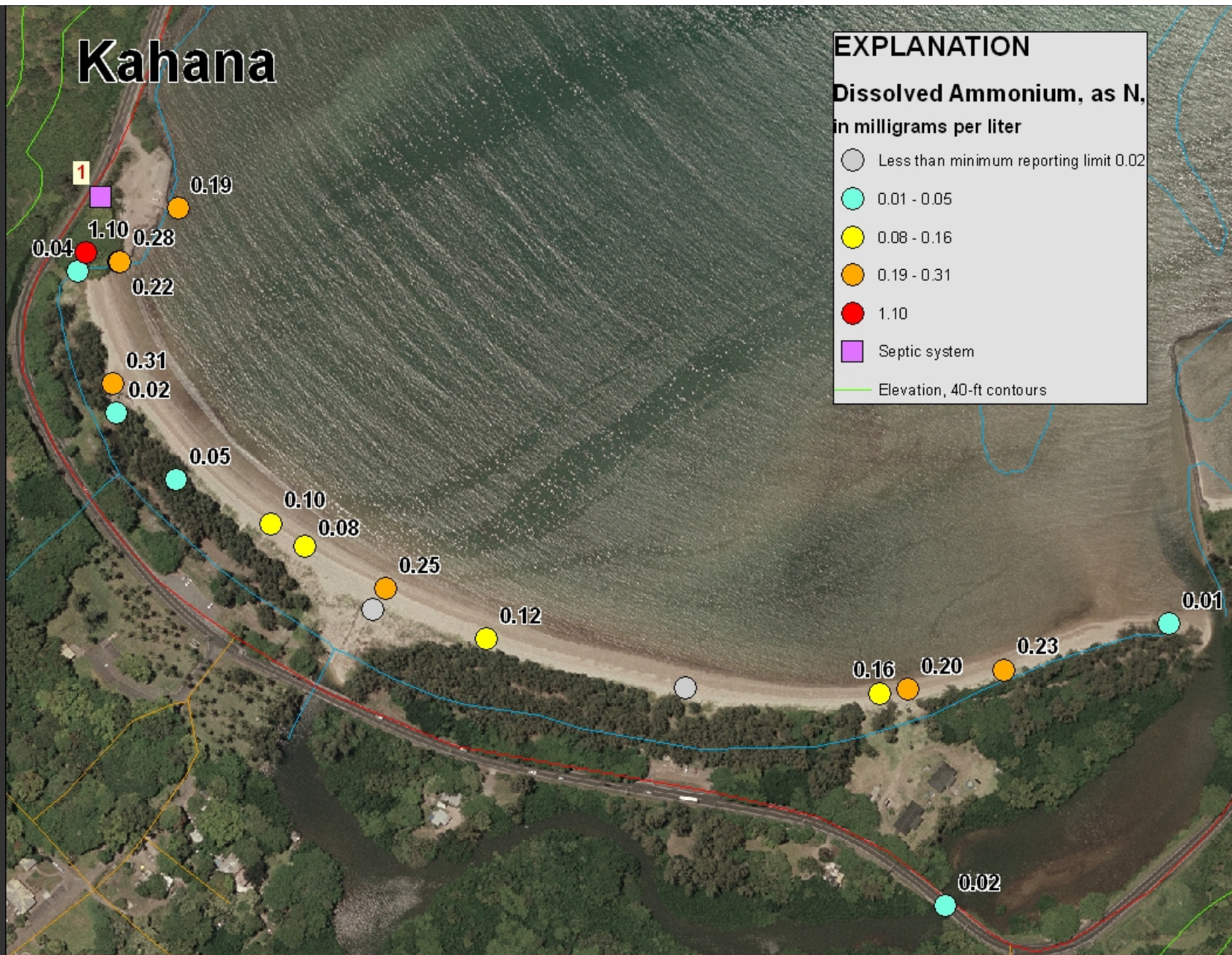


Kahana

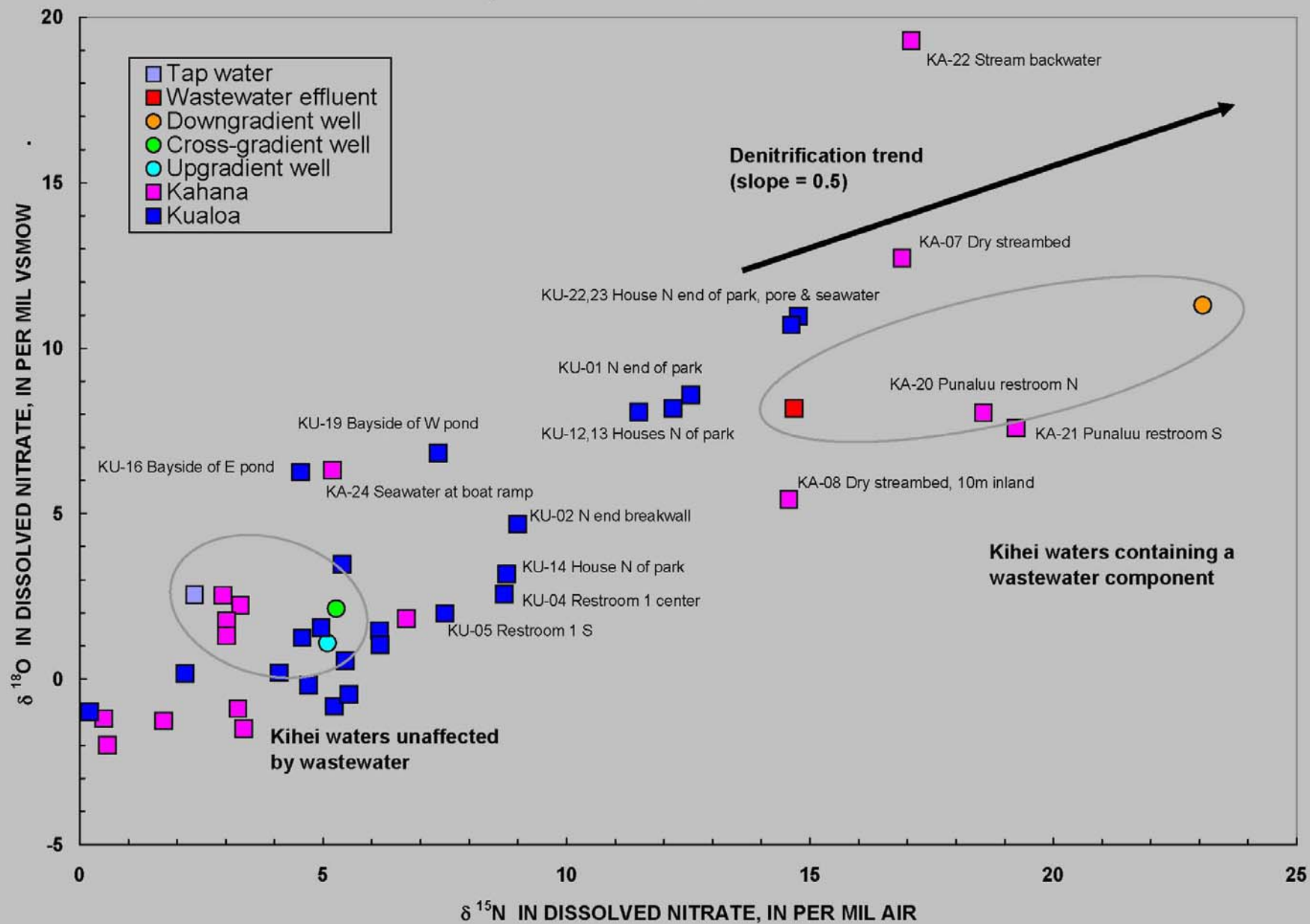
EXPLANATION

Dissolved Ammonium, as N,
in milligrams per liter

- Less than minimum reporting limit 0.02
- 0.01 - 0.05
- 0.08 - 0.16
- 0.19 - 0.31
- 1.10
- Septic system
- Elevation, 40-ft contours



Compare ^{15}N at Kualoa & Kahana to Kihei



Conclusions

Overall

Kualoa Beach

Restrooms

North cove and farther

Kahana Bay

Punaluu Beach Park

NW cove

- **Wading & porewater methods have proven out → interpretable maps**
- **No** strong multi-tracer wastewater signature; slight indication NO_3 & PO_4
- **Probable animal / human waste signature; enhanced GW discharge**
- **Strong** multi-tracer wastewater signature; good septic endmember
- **No** strong multi-tracer wastewater signature; enhanced GW discharge, denitrification (of natural N?)

Refinements & Further Work

- Retrospective bacteria vs rainfall time-series
 - wet or dry problem? (can do now with existing data)
- Begin to evaluate overland runoff sources
- Fluorescence sensor on multiparameter probe
- Conduct bacterial transects with wading surveys
- Denser beach porewater transects to make sure we're not missing possible restroom "plumes"
- Targeted sampling for pharmaceuticals, wastewater indicator compounds, major ions
- Closer attention to redox conditions
- Ultimately – Bacterial source-tracking methods?

Wet or Dry Problem?


Jan 12, 2007

(most recent beach closure)

Kualoa closed to swimmers
because of bacteria count

Honolulu Advertiser

Jan 12, 2007



Jan 8, 2007
Storm runoff:

**Though Waikane Stream ran full
yesterday from heavy rain, it did
not overflow.**

**Honolulu Star-Bulletin,
Jan 9, 2007**

Photo: F.L. Morris, Honolulu Star-Bulletin

Other Relevant USGS Studies

- Bacterial contamination, Huntington Beach
- Sources of microbial contamination at public beaches, Santa Barbara
- Enterococcus surface protein indicator of human fecal pollution, Russian River
- Pathogen Exposure through Recreational Water
<http://health.usgs.gov/pathogens/>
 - Microbial Source Tracking page
 - Lots of Great Lakes work

Hanalei Beach Park & River



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Photos: HawaiiWeb, Inc.

Kaelepulu Pond, Kailua (TMDL)

